CHAPTER 2

DRAWINGS AND SPECIFICATIONS

INTRODUCTION

Working with drawings and specifications (specs) is an essential part in your development as a Construction Electrician. You must be able to interpret, plan, estimate, and schedule construction projects, using the information supplied by the drawings and specifications. You will need to picture the separate operations mentally as the work progresses through the various stages of construction. You must use good judgment when determining what effect numerous factors and conditions have on a project and what allowances should be made for each of them. You must have ready access to information about the material, the equipment, and the labor required to perform various types of work under conditions encountered as part of the Naval Construction Force (NCF). In this chapter, we discuss this important phase of your work, that is, working with drawings and specifications.

Project concepts are developed by local activities. Their supporting documentation for a construction project is forwarded to NAVFACENGCOM, Engineering Field Division (EFD), for requirement validation, technical adequacy of the design solution, and reasonable cost estimate. Once a project has been designed, approved, and funded, it then must be accepted by COMSECOND/COMTHIRDNCB for tasking to the Seabee community. Your first encounter with a project that may have taken years to develop and fund will be the drawings and specifications.

From the beginning (a facility deficiency) to the end (a deficiency corrected), an involved process takes place. As a member of the NCF, you are the person who makes the needs and ideas of the naval community come to reality.

DEFINITIONS

To be able to work with, and from, drawings and specifications, you must know the terms commonly associated with planning, estimating, and scheduling. We have defined a few of the terms you will need to do your job. Read them with care, but do not try to memorize them. Remember where you found them so you can refer to these terms whenever you have to use them.

Activity estimates consist of a listing of all the steps required to construct a given project. Activity quantities provide the basis for preparing the material, equipment, and manpower estimates. They are used to provide the basis for scheduling, material deliveries, equipment, and manpower.

Bill of material (BM) is a tabulated statement of the material required for a given project. It contains such information as stock numbers, unit of issue, quantity, line-item number, description, vendor, and cost. Sometimes the bill of material will be submitted on either material estimate sheets or material takeoff sheets; the two sheets contain similar information. Usually, the takeoff sheet is an actual tally and checkoff of the items shown, noted, or specified on the construction drawings and specifications.

Construction activities are a breakdown of master activities. They identify functional parts of the project and are often assigned to a particular company (Bravo/Charlie) or rating.

Detailed estimates are precise statements of quantities of material, equipment, and manpower required to construct a given project. Underestimating quantities can cause serious delays in construction or can result in unfinished projects. A detailed estimate must be accurate to the smallest detail to quantify requirements correctly.

Direct labor includes all the labor expended directly on assigned construction tasks, either in the field or in the shop, that contribute directly to the completion of the end product.

Equipment estimates consist of a listing of the various types of equipment, the amount of time, and the number of pieces required to construct a given project.

Estimating is the process of determining the amount and type of work to be performed and the quantities of material, equipment, and labor required.

Indirect labor includes labor required to support construction operations but does not. in itself. produce an end product.

Manpower estimates consist of a listing of the number of direct labor man-days required to complete the various activities of a specific project. These estimates may show only the man-days for each activity or they may be in sufficient detail to list the number of man-days for each rating.

Master activities consist of a breakdown of a complete project in sufficient detail to provide a comprehensive description of the project.

Material estimates consist of a listing and description of the various materials and the quantities required to construct a given project. Information for preparing material estimates is obtained from the activity estimates. drawings, and specifications.

Planning is the process of determining requirements and devising and developing methods and a scheme of action for construction of a project. Good construction planning is a combination of various elements: the activity, material, equipment, and manpower estimates: project layout; project location; material delivery and storage; work schedules; quality control; special tools required; environmental protection: safety; and progress control. All of these elements depend upon each other. They must be taken into account in any well-planned project.

Preliminary estimates are made from limited information. such as the general description of projects or preliminary, plans and specifications having little or no detail. Preliminary estimates are prepared to establish costs for the budget and to program general manpower requirements.

Scheduling is the process of determining when an action must be taken and when materials, equipment, and manpower will be required. It shows the sequence, the time for starting, the time required for performance. and the time for completion.

SPECIFICATIONS

Specificationsare written information about how a building or project is to be built. They are prepared under the direction of the architect and engineer. The type and quality, of materials, workmanship, finish. and final appearance are spelled out. The written specifications, along with the drawings. should give all the information needed to complete any project. Specifications control the actions and performance of all parties who are working on or supplying material to a construction project. Specifications may be only a few pages long and give general instructions and specific information on materials. Short specifications are common in small construction jobs. In heavy construction. however. specifications may run hundreds of pages. Unless you understand how the various parts of he specifications interrelate. the sheer mass of the written material can be confusing. Specifications are composed of three major parts:

- Bid and contract forms
- General conditions
- Technical specifications

As an electrician, you will be working with specifications that deal with the technical areas related to your job. You will be responsible for the general and supplemental specifications. special conditions. and addenda or changes to conditions that may affect you.

The technical specifications spell out exactly what material is to be used. what standards are to be met. and what work is to be done in all areas ofconstruction. The Construction Specification Institute (CSI) has developed a standard format that is widely followed to develop complete specifications. Bidding and contract requirements are covered in Division 0. Technical specifications are covered in Divisions 1 through 16. Division 17, expeditionary structures, was established specifically by, NAVFAC. As you can see from table 2-1, the specifications are arranged in the sequence in which the project will progress. starting with bidding and contract requirements.

CONSTRUCTION DRAWINGS

The main basis for defining the required activities, measuring the quantities of material, and making accurate estimates is the information contained in construction drawings. You should read all notes and references carefully and examine all details and reference drawings thoroughly. You should check the orientation of sectional views carefully. Verify the Revision section near the title block to check whether the indicated changes were in fact made in the drawing itself. When inconsistencies are found between drawings and specifications. the specifications should take precedence.

Drawings are generally categorized according to their intended purposes: **preliminary drawings. presentation drawings. working drawings.** and **shop drawings.**

Table 2-1.—Technical Specifications

DIVISION #	AREA OF CONSTRUCTION
• Division 0	Bidding and Contract Requirements
• Division 1	General Requirements
• Division 2	Site Work
• Division 3	Concrete
• Division 4	Masonry
• Division 5	Metals (Architectural and Structural)
• Division 6	Wood and Plastics
• Division 7	Thermal and Moisture Protection
• Division 8	Doors and Windows
• Division 9	Finishes
• Division 10	Specialties
• Division 11	Equipment
• Division 12	Furnishings
• Division 13	Special Construction
• Division 14	Conveying Systems
• Division 15	Mechanical
• Division 16	Electrical
• Division 17	Expeditionary Structures

A building project may be broadly divided into two major phases: the design phase and the construction phase. First, the **preliminary drawings** are prepared during the design phase. They are prepared by the EFD or by an architect's and engineer's (A/E) firm. The preliminary drawings are used for exploring design concepts between the designer and the user (customer), making material selection, getting preliminary cost estimates, and serving as a basis for preparing the finished working drawings.

The **presentation drawings** are developed to show the proposed building or facility in an attractive setting in its natural surroundings at the proposed site. Since these drawings are actually used to sell an idea or a design, you will probably see this type of drawing only as a cover sheet to a set of construction drawings.

In the second phase, after approval has been given for construction, the **working drawings** are developed. **Shop drawings** are supplied by manufacturers to show fabrication of building parts. After review by the architect and engineer, they become a part of the working drawings. Throughout your career, you will hear working drawings referred to as blueprints, construction drawings, prints, or plans. Basically, these terms are all correct; they can be used interchangeably.

As mentioned earlier, the construction drawings are developed from the preliminary drawings. With the collaboration of the EFD and the architect and the engineer, both the materials to be used and the

construction methods to be followed are decided. The engineer determines the loads that the supporting structural members will be required to bear and designs the mechanical systems. such as heating. power. lighting, and plumbing.

As a crew member or a supervisor. you will find the construction drawings. the specifications. and the bill of material your main sources of information during the construction and estimating phases of the project.

Drawings are commonly indexed so you can easily find the sheet you need. The drawing index is located on the cover sheet or sheet 1 of the set. They are divided into eight categories and appear in the following order:

1. Plot and vicinity
2. Landscape and irrigation
3. Architect
4. Structural
5. Mechanical
6. Plumbing
7. Electrical
8. Fire protection

WORKING SKETCHES

A working sketch is a drawing made from the working drawings to express a tasking clearly and to provide a quick reference to job requirements. It is drawn to help show actual conditions on the job, what size pipe is to be installed, or where connections will be made. The sketch should show as much detail as possible to help your crew during installation or troubleshooting. A working sketch will usually show the work you want your crew to accomplish in a selected area and will provide ready reference to jobsite conditions.

A crew should have a working sketch with them while working. It will show them how, what, where, and when things happen in the sequence of the job. Your first step in making a working sketch should be to draw the symbols that represent all the fixtures or equipment that is to be installed and locate them within the room. Try to draw them in the sequence of installation and include measurements. The amount of detail you use in a working sketch will be determined by the crew's experience, the complexity of the systems involved, and the need for cooperation with other trades working on the jobsite.

AS-BUILT DRAWINGS

Upon the completion of a facility, the crew leader or project supervisor should provide marked prints that indicate any construction deviations. The information required must show all features of the project as actually, built. As-built drawings should be reviewed after they are completed. This review assures that all information appearing on the drawings shows the exact as-built conditions.

From the as-built drawings, record drawings are prepared. These drawings are the original construction drawings, but they are corrected according to the as-built marked print. They then provide a permanent record of as-built conditions. The final record drawings must be kept up to date at all times. If this maintenance requires a change to the record drawing, then this information should be passed on and the record drawings updated.

BLUEPRINT LANGUAGE

To understand the instructions and dimensions on a working drawing, you must be able to read and understand the language of the prints not only for your particular job but also for all the different phases. Plans, specifications, and details go together. It is impossible to use one successfully without the other. Never overlook a reference note on a drawing. The blueprints contain the information and directions that require you to do your part of the total job as planned. It is also important to follow all the instructions on a blueprint faithfully. Any deviation on your part may make it impossible for fellow tradesmen to do their work properly or successfully.

To read blueprints, you must understand the meanings of all devices, such as various lines, symbols, conventions, abbreviations, and methods of giving dimensions and working directions.

TYPES AND WEIGHTS OF LINES FOUND ON DRAWINGS

The types of lines the electrician should be able to read and understand are given below. In figure 2-1 these lines are shown as they may appear on a drawing.

Trim line: a light, continuous line along which the tracing is trimmed to square the sheet.

Border line: a heavy, continuous line that outlines or borders the drawing. The drawing is complete within this lined border.

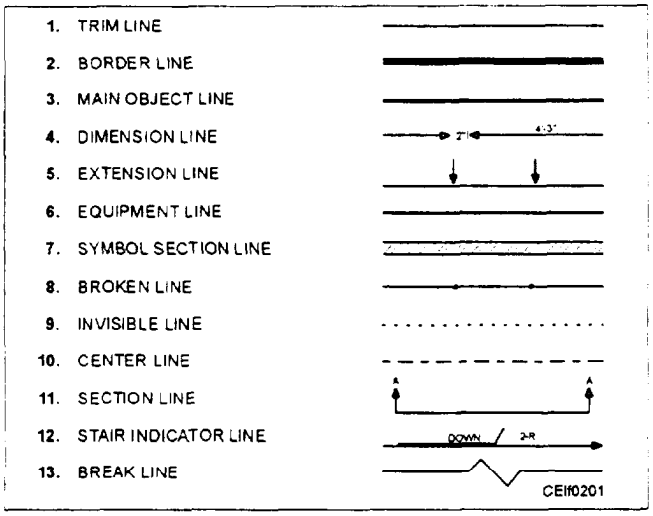

Figure 2-1.—Construction drawing lines.

Main object line: a heavy, unbroken line used to show visible outlines or edges that would be seen by people looking at the article, house, or building. The main object line is one of the most important lines because it outlines the main wall lines on plans and sections. It shows clearly the important parts of the construction and emphasizes the outline of the elevations.

Dimension line: a light line drawing outside the structure or detail to show the distance between two points. This line is drawn between extension lines with an arrowhead on each end. Between the arrowheads, the distance will be given either at a break in the line or just above the line. On some drawings the scale and the distance between the two points may not agree; in such cases, the distance will be given in a dimension line.

Extension line: a line that touches and is used with dimension lines. This line extends out from the edge or the point at which the dimension is to be determined.

Equipment line: a light, continuous, unbroken line used to show the location of equipment, such as transformers, panels. and galley equipment. This line is used to allow the electrician to install the necessary conduit in the proper location during rough-in work.

Symbol section line: lines that are generally solid, although, for certain conventions, dotted lines of the same weight may be used. Section lines, evenly spaced, are used to shade surfaces shown on a drawing and by these means indicate the material used. Material section lines are standardized to a certain degree, but you will find some variations. A set of working drawings using these symbols would have a symbol schedule key showing the various materials in that particular set. This schedule is usually placed near the title box on the plan of the first floor.

Broken line: a line with wavy breaks in it, at intervals, used to indicate those parts that have been left out or that the full length of some part has not been drawn. The broken line is used in detail drawings where only a section of the object is to be shown.

Invisible line: a line that is made up of a series of short dashes. It is used to indicate a hidden or an invisible edge or edges that are hidden under some other part of the structure.

Center line: a line that is made up of alternating long and short dashes and is used to indicate the center of an object.

Section line: a solid line that has arrowheads at each end that point in the direction in which the section is to be taken. This line tells just where the section line has been cut through the wall or building. The sections are indicated, in most cases, by the letters *A-A, B-B,* and so forth, although numbers are sometimes used. Do not overlook these section lines on a plan. To obtain a clear picture of the construction at the particular point indicated, always refer to the section detail called for by the letter or number.

Stair indicator line: a solid line with an arrowhead indicating the direction of the run. For example, Up 12-R means that there are 12 risers from floor to floor and that the stairs go up. A riser is the vertical part of the step; the flat part on which one steps is the tread. In most cases, the floor plan indicates only the run of stairs half the distance between floors. For example, the ground floor indicates a broken line that tells you the steps continue up. The next floor plan shows the stair indicator line half the distance to the first floor, down.

Break line: a thin solid ruled line with freehand zigzags used to reduce the size of a drawing required to delineate an object and reduce detail.

ABBREVIATIONS AND SYMBOLS

Blueprints show a small-scale drawing of a full-size building. Since the blueprints are small in relation to the actual building, some kind of shorthand is needed to give the necessary building information. Abbreviations and symbols are used to show a large amount of information in a small space.

While there is some standardization of symbols and abbreviations, a lot of variation still exists. A key or legend is put on the blueprint to explain their uses.

An abbreviation is a shortened form of a word. Sometimes the same abbreviation is used for different words. The specific meaning of an abbreviation can be determined by its use on the blueprint. Abbreviations are used in notes or as specific characters on the blueprints. The area referred to will give a hint to the meaning of the abbreviation.

Symbols are used on blueprints to represent materials, equipment, electrical. mechanical, plan. elevations, and sections (figs. 2-2 through 2-9). They are used as a simple way of representing a fact. Most drawings have a legend of symbols which, when combined together with the specifications, describes a building thoroughly.

SCHEDULES

The schedule is a systematic method of presenting notes and information in a tabular form for the purpose of making it easily accessible to the craftsman and specification writer. One example of a commonly used lighting fixture schedule is shown in figure 2-10. Similar schedules such as the room finish schedule and the mechanical equipment schedule (not shown) are very helpful and also should be reviewed.

SCALE REPRESENTATION

An architect cannot make his drawings full size. For convenience. he reduces all dimensions to some

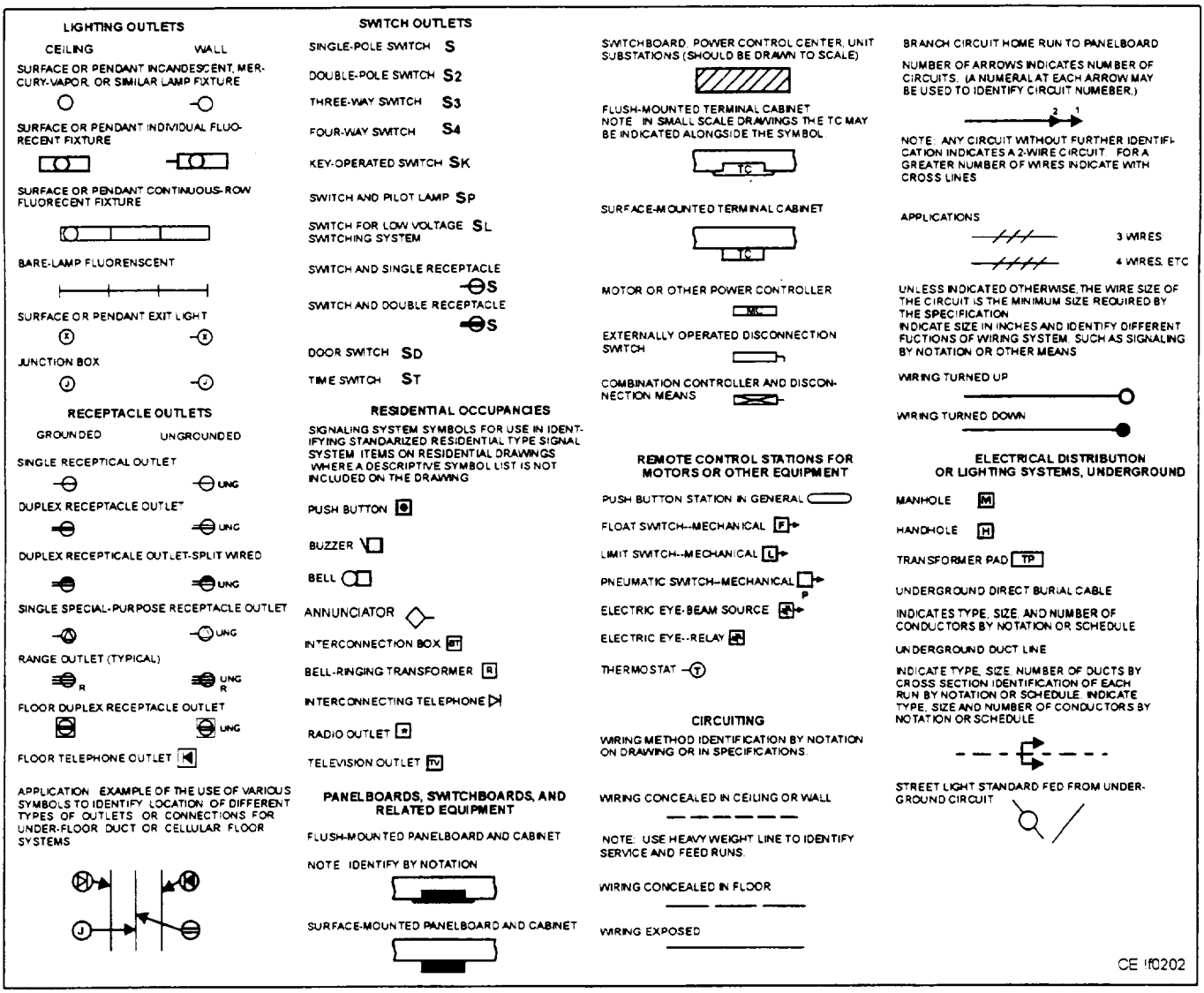

Figure 2-2.—Electrical symbols.

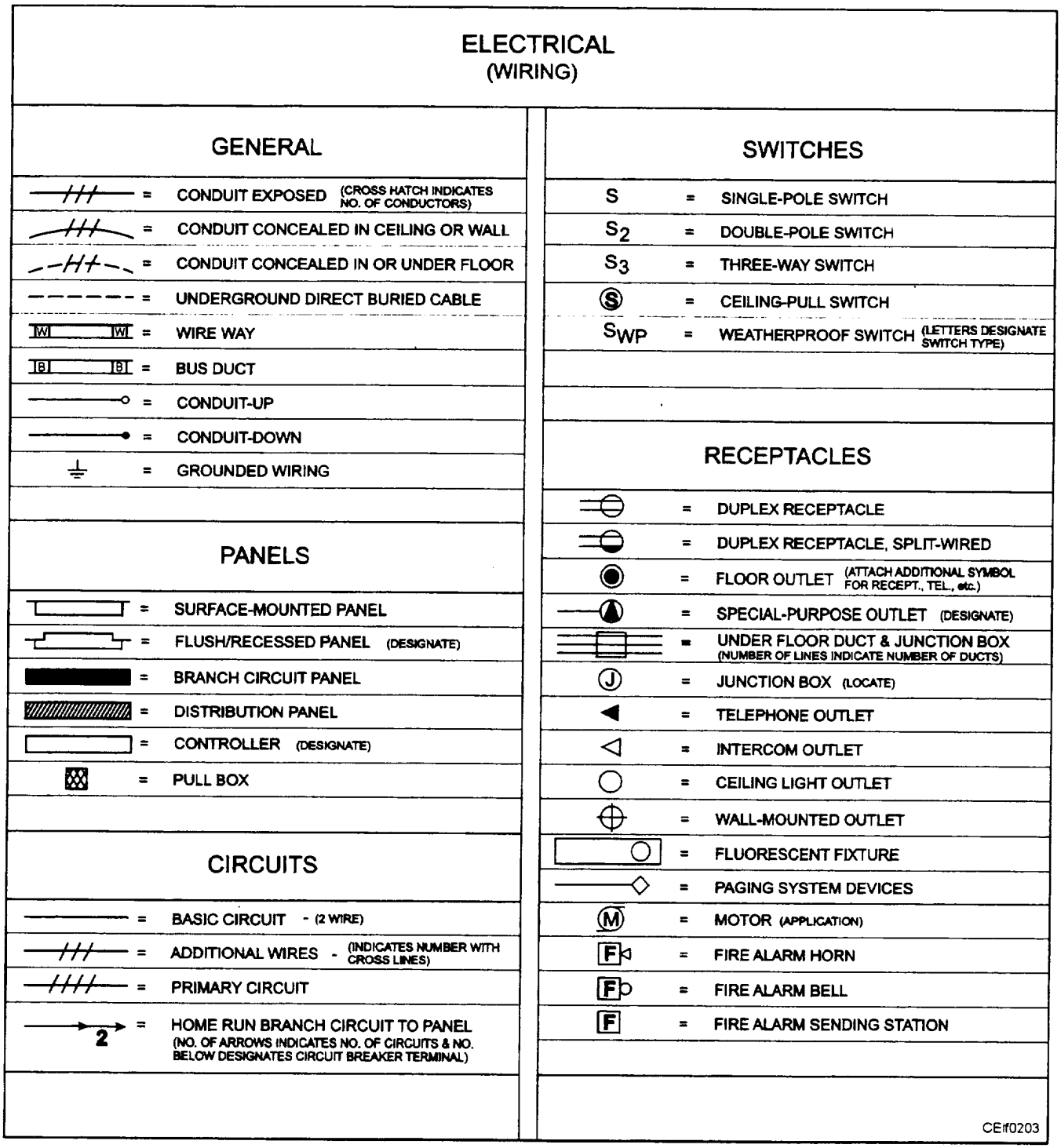

Figure 2-3.—Additional electrical symbols.

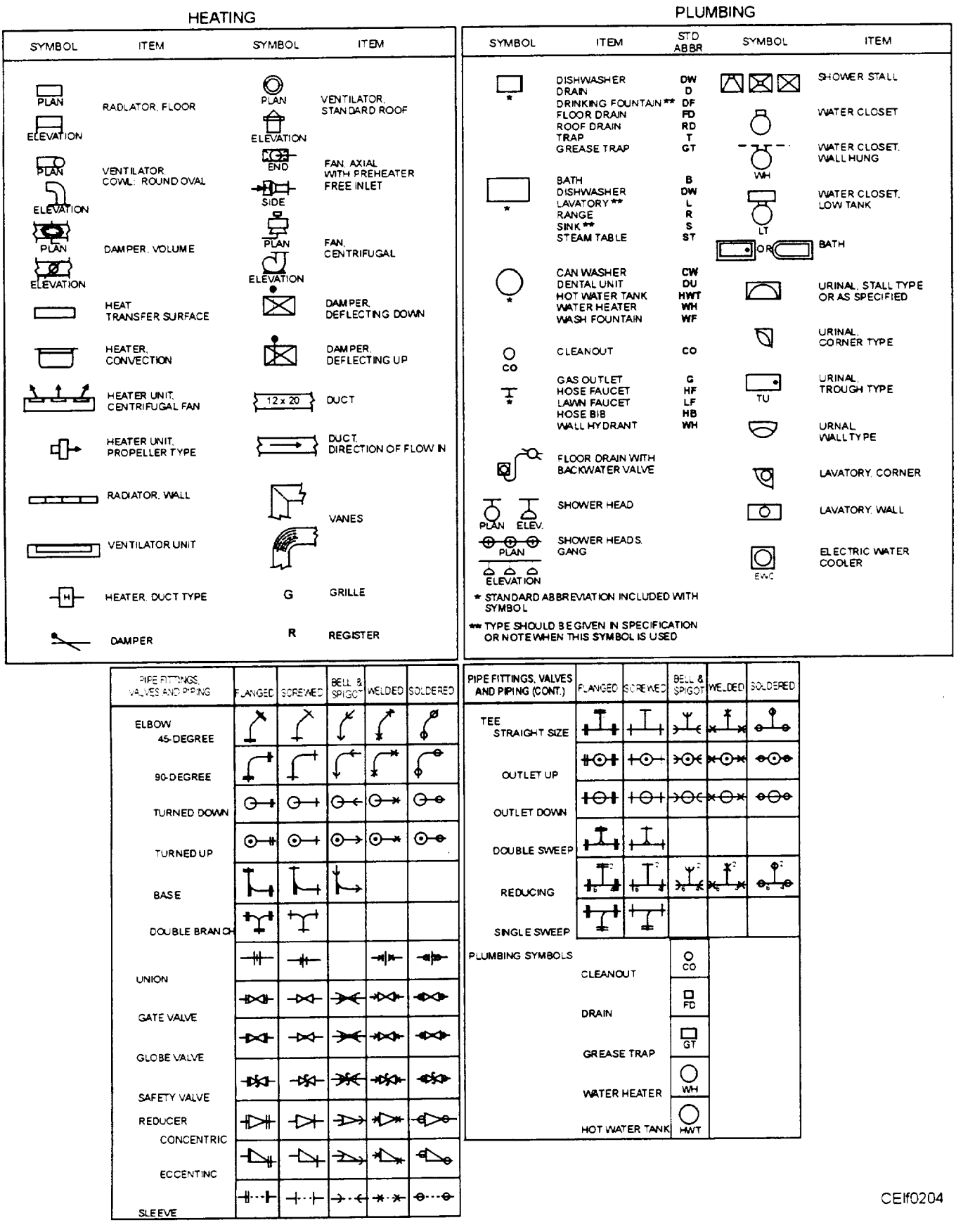

Figure 2-4.—Heating, plumbing and pipe fitting/value symbols.

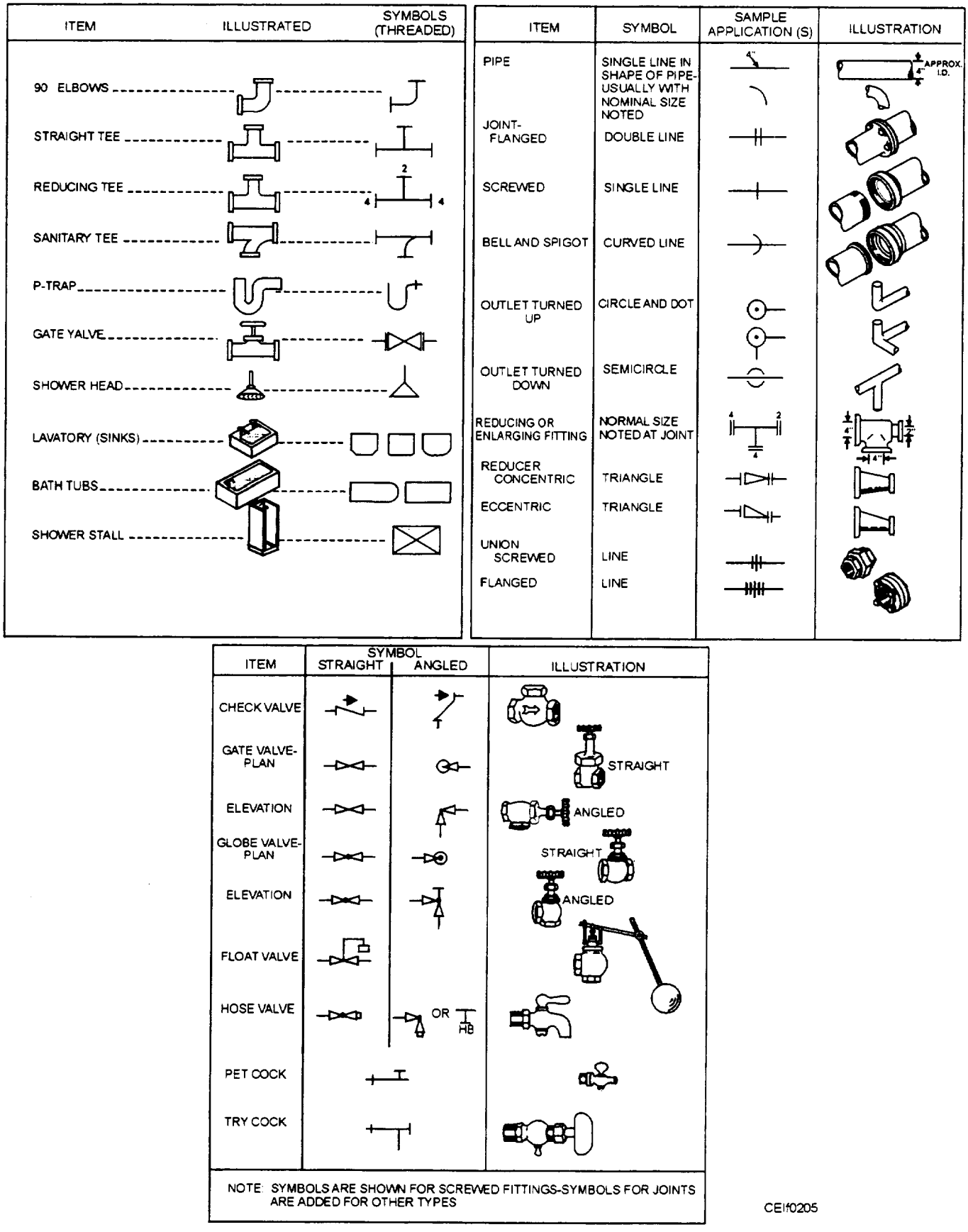

Figure 2-5.—Mechanical and plumbing symbols.

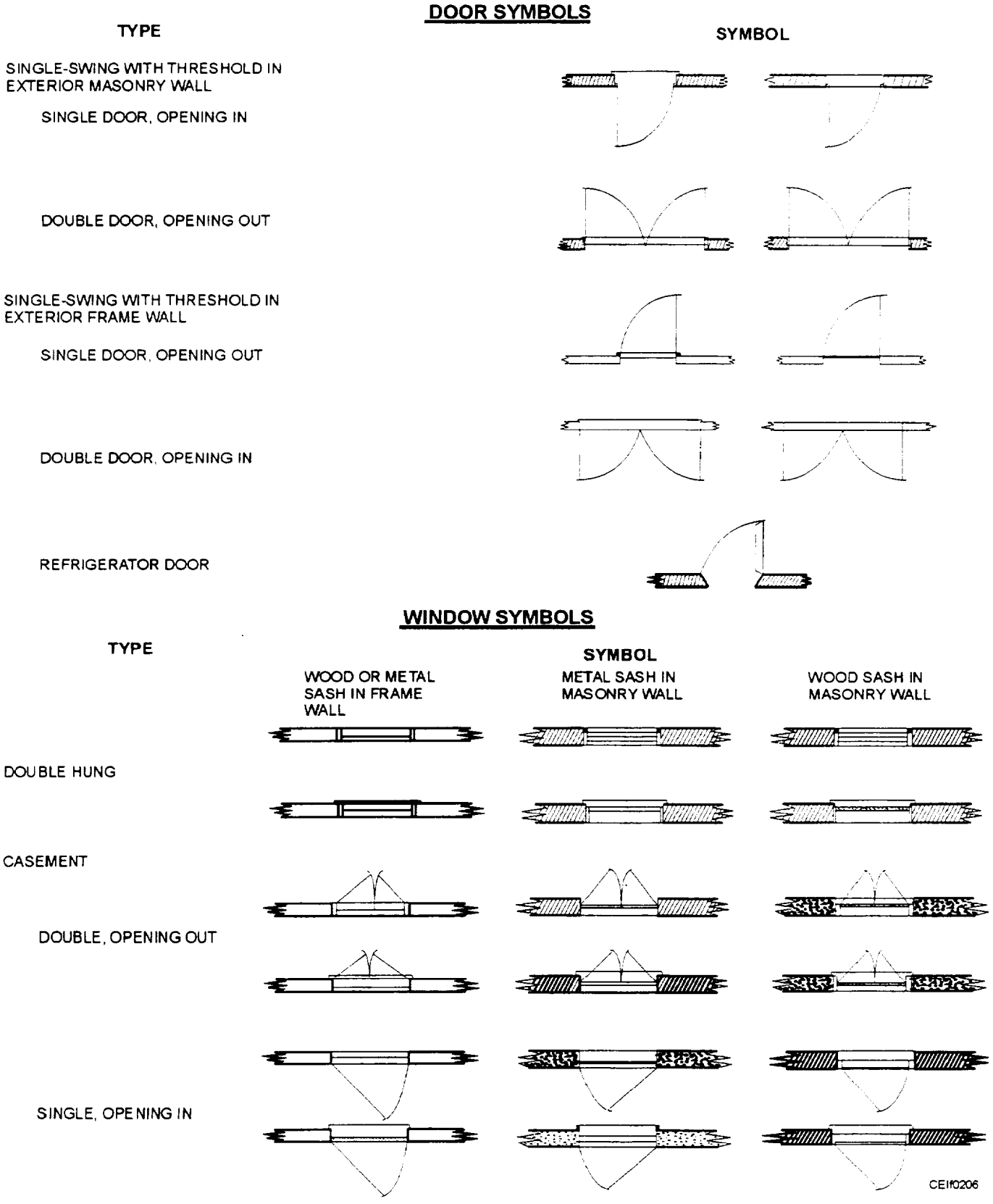

Figure 2-6.—Architectural symbols for doors and windows.

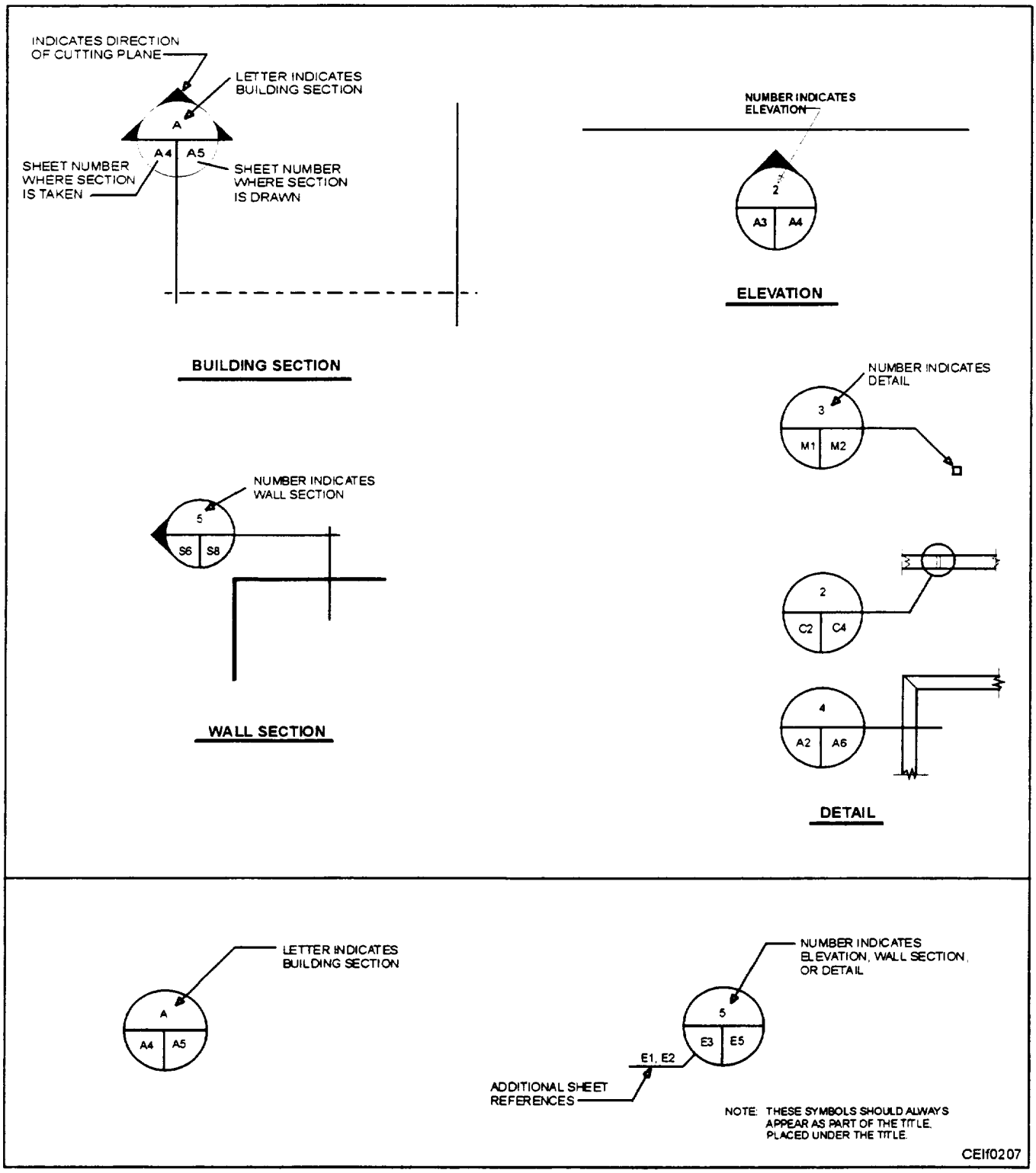

Figure 2-7.—Title symbols.

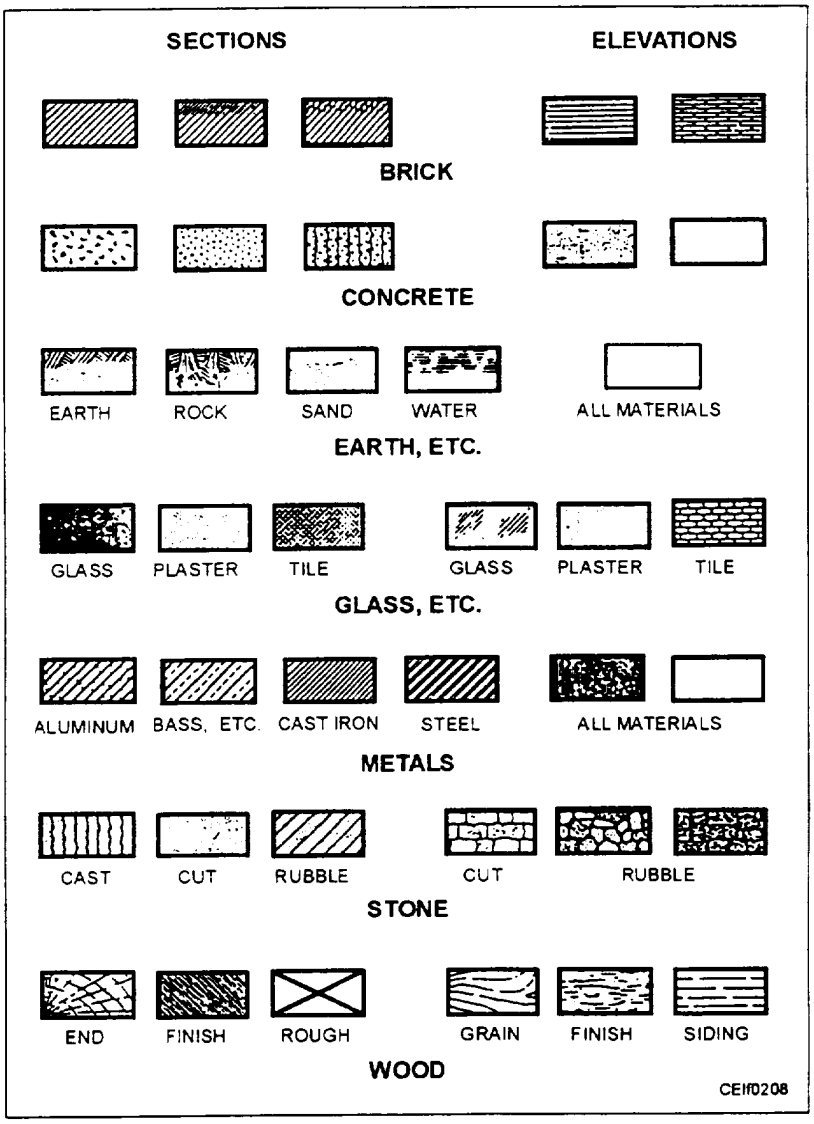

Figure 2-8.—Architectural symbols for plans and elevations.

scale. He selects some smaller dimension to represent a foot and reduces all dimensions to this unit. A floor plan or an elevation is often drawn at l/48 the size of the real building. A drawing 1/48th size would be drawn at a scale of 1/4" = 1'0". Each l/4 inch on the drawing equals 1 foot on the actual building. Different scales are used to show different areas of the drawings. While floor plans and elevations are commonly drawn l/4" = 10, detail drawings are drawn at a larger scale, usually 1" = 10. Sometimes full-scale drawings are used to show a small detail. The scale is normally noted in the title block or beside each drawing on the print.

Scaled drawings are made using an architect's scale (fig. 2-11). An architect's scale has 11 scales (table 2-2). The numbers at each end of the architect's scale designate the scale. Figure 2-12 shows an enlarged view of part of a l/4-inch scale. Each division on the scale equals 1 foot on the actual building. The small divisions to the right equal 1 inch on the building, thereby allowing more accurate measurement. This scale is read from right to left. Architects and drafters use an architectural scale to draw blueprints. Figure 2-13 shows how the scale is used to check a measurement on a blueprint. Note how the small divisions (at the right) are used to get exact measurements; in this case, 8 feet 8 inches.

MODULAR DIMENSIONS

Some blueprints are drawn so that features on the structure fall within a set module or measure. A modular system is based upon a grid with a set measure, normally 4 inches or a multiple of 4 inches, such as 16. 24, or 48 inches. Walls, floor levels, and

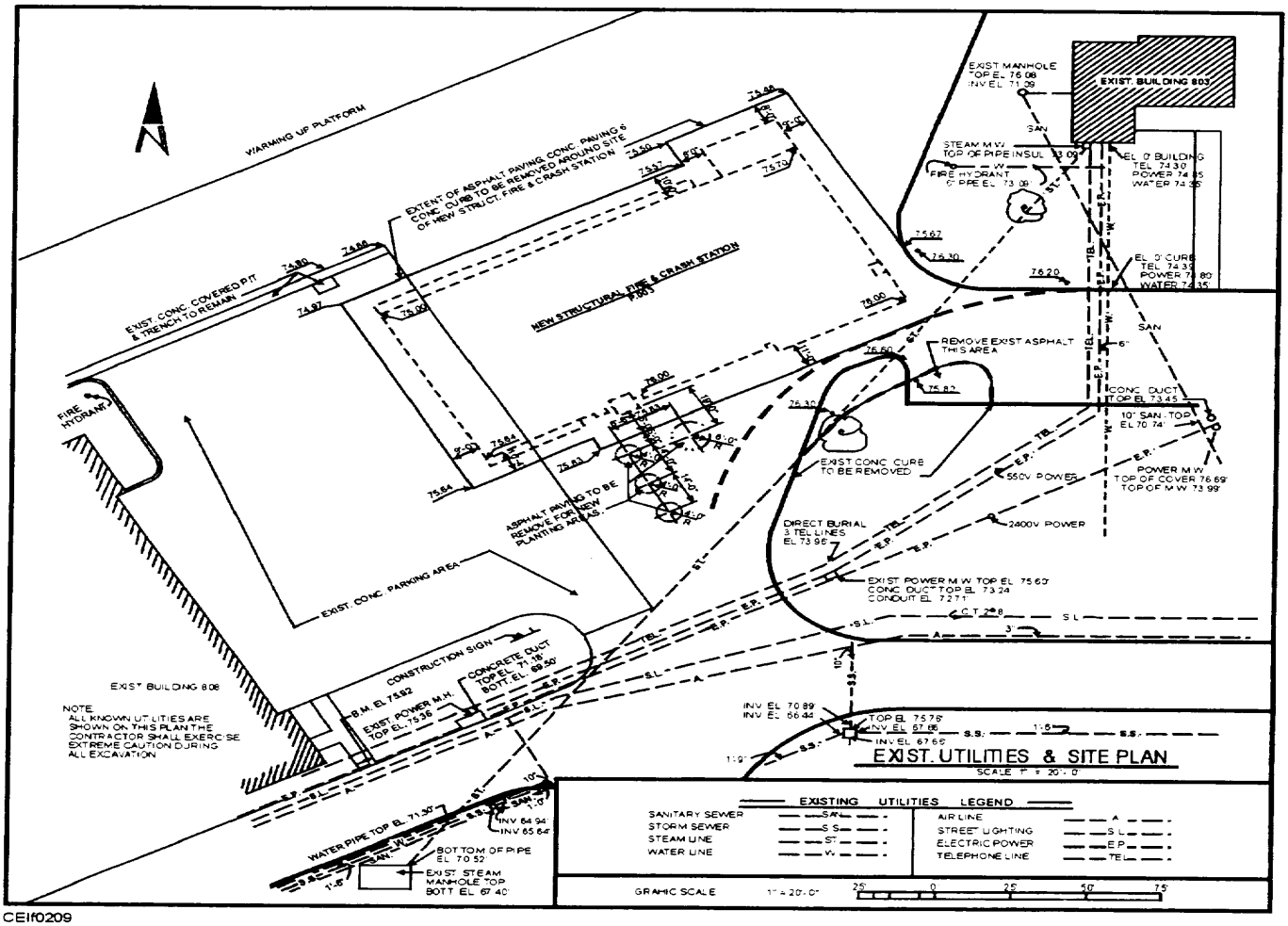

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Figure 2-9.—Plot plan, contours, and symbols.

openings are dimensioned to fall on 4-inch modular lines. This approach reduces building costs by coordinating building sizes with standard-sized building materials. For example, studs with finish are approximately 4 inches thick and are spaced on 16- or 24-inch centers. Plywood panels and drywall sheets come in standard 4-foot by 8-foot sheets.

Figure 2-14 shows a modular light-frame house used for a small residential building. The building is laid out in such a way that standard modular-based building materials can be used. Often, modular construction is used to develop complete, finished panels or rooms. This process allows standard-size building parts to be fabricated, taken to the building site, and erected into place.

METRIC DIMENSIONS

Metric measurement is becoming more common in the United States on construction working drawings. NAVFAC drawings now have dimensions in both metric and English. The metric scale is used in place of the architect's and engineer's scales when measurements and dimensions are in meters and centimeters.

LIGHTING FIXTURE SCHEDULE					
MARK	DESCRIPTION	MTG	VOLT	LAMPS	REMARKS
A	ALKCO # EXPRC-210-2E/120V/GREEN LETTER. ON CLEAR	CEILING	277	(2) 6 WT5	W/FLASHER
B	METALUX # SS 240-277-ES	PENDANT	277	(2)F40/WW/RS/ WMII	W/1 ½ HR BATT PACK
C	ROBERT MFG # 72-240-277-ES	SURFACE	277	(2)F40/WW/RS/ WMII	W/1 ½ HR BATT PACK
D	METALUX # HR-2GP-ASR-3 40A-125-277-LE3	RECESSED	277	(3)F40/WW/RS/ WMII	BLDG STANDARDS
E	CROUSE-HINDS # VXHB15GP	WALL	120	(1)150W/A21/ 130V	
F	METALUX # HR-2GP-ASR-3 40A-125-277-LE3	RECESSED	277	(3)F40/WW/RS/ WHII	BLDG STANDARDS W/1 ½ HR BATT PACK
G	SURE LITE # SWV-36	RECESSED	120/6	SUPPLIED W/ FIXTURE	W/1 ½ HR BATT PACK
H	METALUX # SS 230-277-ES	COVE	277	(2)F40/WW/RS/ WM	
I	METALUX # SS 240-277-ES	PENDANT	277	(2)F40/WW/RS WMII	
J	LIGHTOLIER # JAW04II	WALL	120	(1)60W/G-40/CL	BLACK W/CLEAN SPHERE

CEIf0210

Figure 2-10.—Commonly used lighting fixture.

Table 2-2.—Architect's Scales

SCALE	RELATION OF SCALE TO OBJECT
16	Full Scale
3	3" = 1'-0"
1 l/2	1 1/2" = 1'-0"
1	1" = 1'-0"
3/4	3/4" = 1'-0"
l/2	1/2" = 1'-0"
3/8	3/8" = 1'-0"
l/4	l/4" = 1'-0"
3/16	3/1" = 1'-0"
l/8	1/8" - 1'-0"
3/32	3/23" = 1'-0"

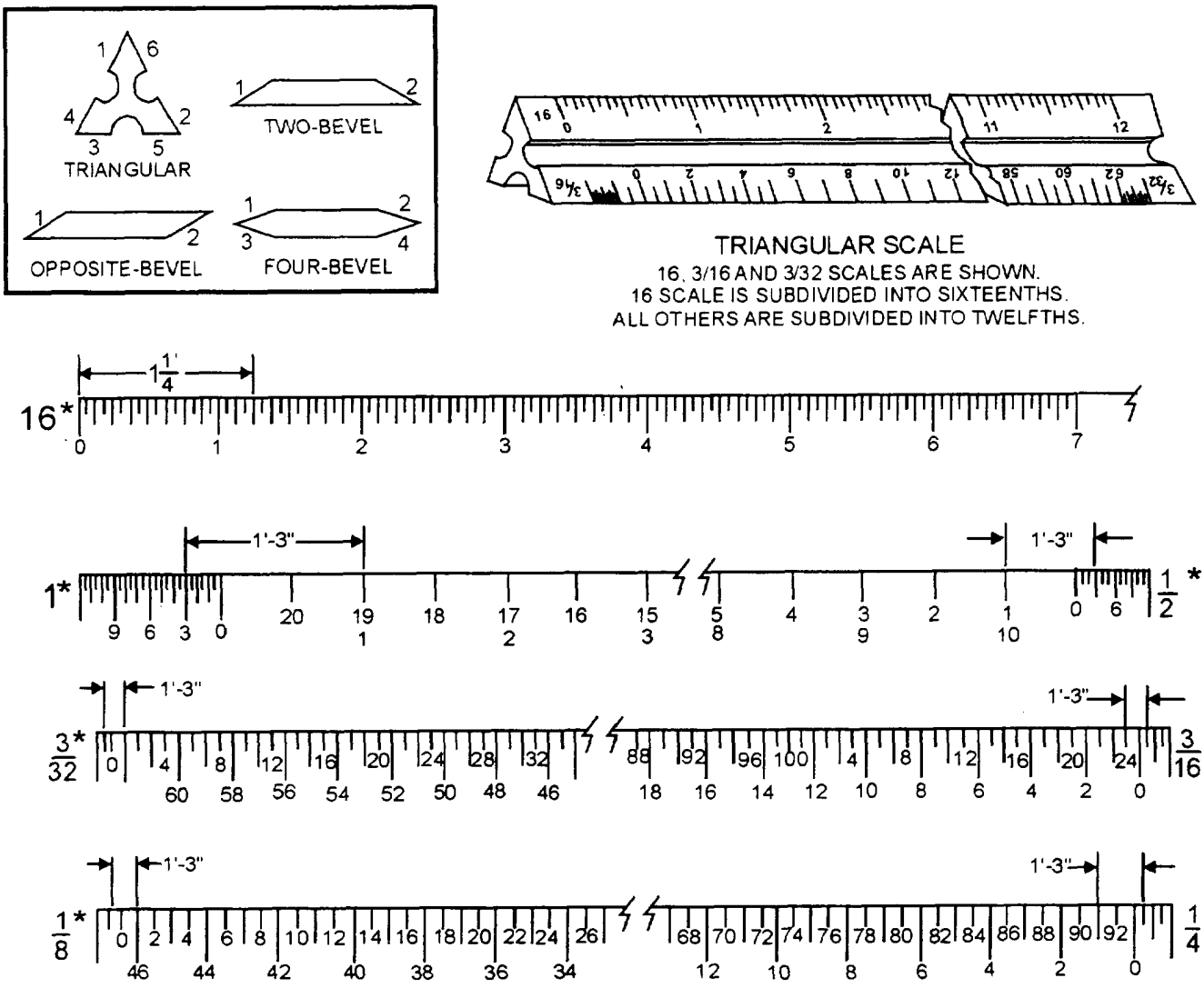

Figure 2-11.—Architect's scale.

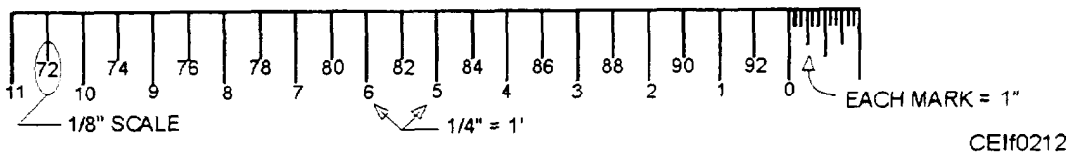

Figure 2-12.—Enlarged view of part of a l/4-inch scale.

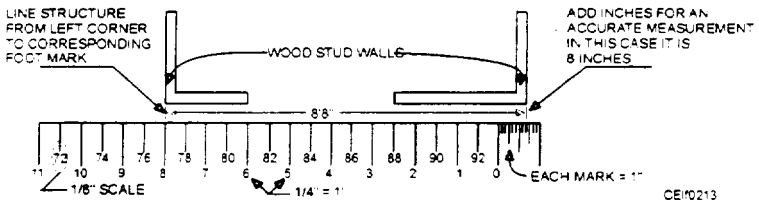

Figure 2-13.—Using a scale to check a measurement on a blueprint.

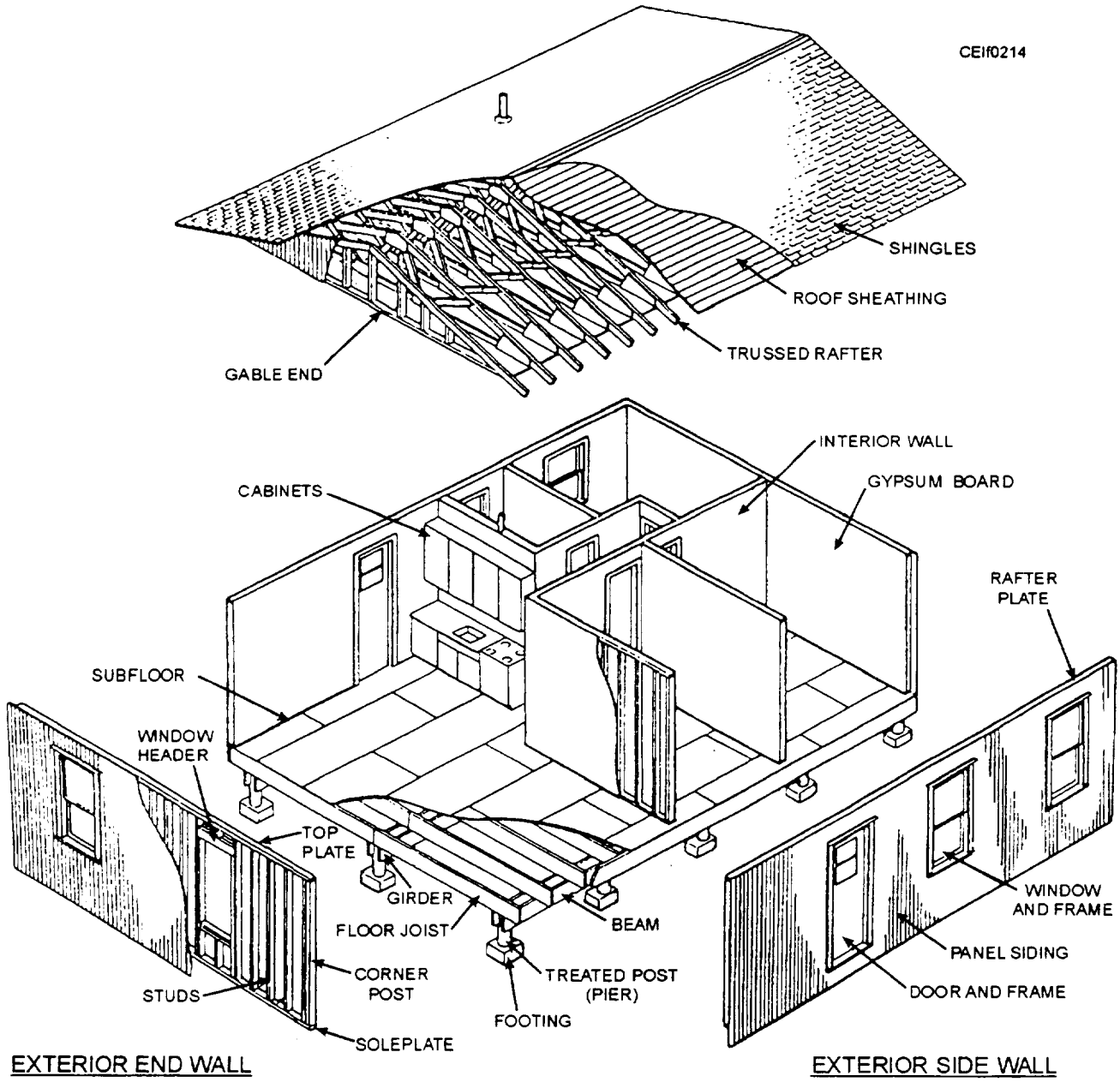

Figure 2-14.—Exploded view of a typical light-frame modular house.

When you are using scales on a drawing, do not confuse the engineer's scale with a metric scale. They are very similar in appearance. You will often find metric dimensions used on blueprints from other countries. Metric drawings are dimensioned in millimeters (mm). There are 25.4 millimeters to an inch. A meter is 39.37 inches, a few inches longer than a yard measure.

Scales of 1:100 and 1:200 are common scales for metric drawings. One millimeter on the drawing represents 100 or 200 millimeters on the actual building.

Metric blueprints developed in the United States are normally marked "METRIC." In countries that use metric, however, no metric notations are made.